Passive Entry Proximity Detection Using Atmel´s QTouch Fast Charge Proximity Acquisition Method

Darius Rydahl

Abstract

Technologies that were once thought of as high-end luxury features on only the most expensive vehicles are slowly finding their way into our everyday lives. Convenience systems like power door locks, passive entry, as well as touch-activated buttons and screens have become common features on the most basic of cars. Now we are beginning to see synergy between these technologies in the form of new and exciting products. Passive-entry proximity detection is one such melding of technologies that has applications in the car access marketplace. Atmel's® QTouch® fast-charge acquisition method can be used to design a passive-entry door handle with proximity detection to meet the ever-expanding needs of the automotive market.

A Short History of Car Access Security

Modern automobile security began with the simple key and door lock. The driver has a key and inserts it into the lock located on the door in order to gain access to the car (see figure 1).

Figure 1. Mechanical Automotive Security – Door Lock and Key

Next came the remote keyless entry (RKE), where a key was no longer required. The driver simply activates a button on a key fob and secret codes are wirelessly exchanged between the remote and the vehicle (figure 2). If the code sent by the key fob is correct, the doors are unlocked.

Figure 2. Wireless Automotive Security – Remote Keyless Entry

Today we have passive entry, and no driver intervention is required to unlock the vehicle. The driver carries a key fob which contains a low-frequency (LF) receiver and wireless transmitter. Pulling the door handle triggers a mechanical switch which initiates the generation of an LF magnetic field around the vehicle (see figure 3).

Figure 3. Wireless Automotive Security – Passive Entry

This field wakes the key fob from sleep and then security codes are wirelessly exchanged between the vehicle and the key fob. The exchange only takes several hundred milliseconds. If the security code is correct, the doors are unlocked before the door handle reaches full extension. If executed properly, there should be no noticeable delay or lag between the initial door handle trigger and the unlocking of the doors. The driver should be unaware of the key-fob-to-vehicle communication that just occurred. It's as if the car doors were never locked.

Car Access Evolution: Passive Entry Proximity Detection

The next step in the evolution of the passive entry car access application is the detection of the driver when approaching the vehicle. This can be accomplished by replacing the mechanical switch used to trigger the LF field with a touch proximity sensor located in the car door handle as shown in figure 4.

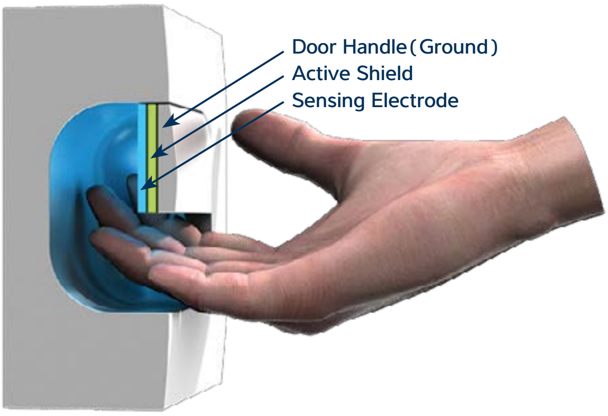

Figure 4. Car Door Handle with Capacitive Proximity Sensing

The capacitive touch sensor is comprised of a sensing electrode, active shield, and a chassis-grounded door handle. The active shield acts as an isolating barrier between the sensing electrode and the door handle. Without this barrier, the proximity detection range of the sensor would be greatly reduced due to the additional capacitive load placed upon the sensing electrode by the door handle itself. With the active shield, the sensor sensitivity is amplified. This increases the proximity detection range.

The sequence of events which lead to the detection of the driver's key fob transponder is much the same as the mechanically-triggered door handle application, except the manner in which the LF magnetic field is triggered. The passive-entry system is triggered by the proximity of the driver's hand to the sensor on the back side of the door handle as the driver approaches the vehicle and reaches for it with his or her hand. The LF field is triggered well before the hand touches the door handle. Triggering the LF field before the driver's hand makes contact with the handle allows for a much faster system response time and increased security through stronger communication algorithms compared to the old mechanically triggered system.

One example of how the passive entry proximity sensing system might be implemented is shown in figure 5. The sequence of driver detection and passive entry unlock of the vehicle doors is as follows:

1. As the driver approaches the car, the hand is detected once it is within range of the proximity sensor, typically 2cm.
2. The proximity sensor wakes the body control module from sleep.
3. The LF driver charges the LF antenna and briefly envelopes the car (or intended approach region) in a magnetic field with a range of 1 to 3 meters.
4. The key fob (carried by the driver) transitions from a very low power listening mode (to conserve battery life) to active mode in response to the field generated by the LF antenna.
5. The key fob wirelessly transmits a security code to the UHF receiver.
6. The RF receiver sends the demodulated security code to the body control module for processing.
7. If the security code is correct, the body control module instructs the door module to unlock the car doors.

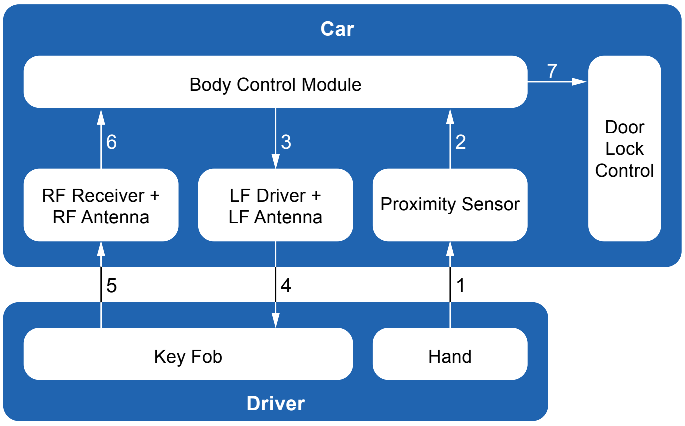

Figure 5. Proximity Sensing Door Handle Block Diagram

Proximity Requirements for Passive Entry Applications

While the specifications for an automotive passive entry proximity-enabled door handle may differ slightly between car manufacturers, the general performance requirements will be similar for most applications. The key requirements for a successful system implementation are:

- **Low Power Consumption –** The average current consumption for a single proximity detection node should be less than 100µA to avoid excessive drain on the battery when the vehicle is not running.
- **Fast Response Time –** The sensor scan rate, the time between sensor readings, should be less than 20ms. A fast scan rate means more sensor readings per second, which will result in earlier detection of the driver's hand as it approaches the door handle sensor. This will mitigate the delay induced by communication processing and enable the car doors to unlock quickly.
- **Simple, Low-cost Interface –** Standard networking interfaces such as CAN or LIN require excessive protocol/processing overhead and are too power-hungry for this low-power application. A simple, more streamlined approach is required, one that utilizes a single-wire, +12V power line data transfer protocol.
- **Robust Environmental Performance –** The proximity sensor must be able to withstand the harsh operating environment that the automobile exterior is exposed to. This means that the sensor must resist the effects of moisture, temperature and localized electromagnetic disturbances.

It is for these reasons that Atmel recommends QTouch fast charge mode as the preferred acquisition method for proximity detection of passive entry automotive applications as opposed to the other Atmel Touch acquisition methods – QTouch, QMatrix® and QTouch ADC.

Why QTouch Fast Charge?

Response Time – As the name implies, it is fast. QTouch fast charge is capable of measuring a single proximity touch sensor channel in **under 2ms**. The average response time is equal to the timer period plus the measurement time when used in conjunction with an Atmel AVR® microcontroller watchdog timer (WDT) as the polling timer for proximity sensing. For example, if the polling interval is set to 16ms, the fastest WDT wake-up period, then the overall response time for QTouch fast charge is approximately 18ms. Given the total response time from LF trigger to a door unlocking is around 200ms, the 18ms it takes to detect a proximity event leaves plenty of processing time for the LF authentication between the remote transponder and the BCM (body control module).

Low Power – The typical current required to measure and monitor a single QTouch fast charge sensor is **less than 100µA** with a 16ms polling period. Current consumption can reach levels as low as 20µA if the polling interval is increased.

Detection Range – With proper sensor design QTouch fast charge is capable of detecting proximity events **over 15cm** in distance. QTouch fast charge is a "self capacitive" sensing technology where the sensor is constructed of a single electrode, see figure 6.

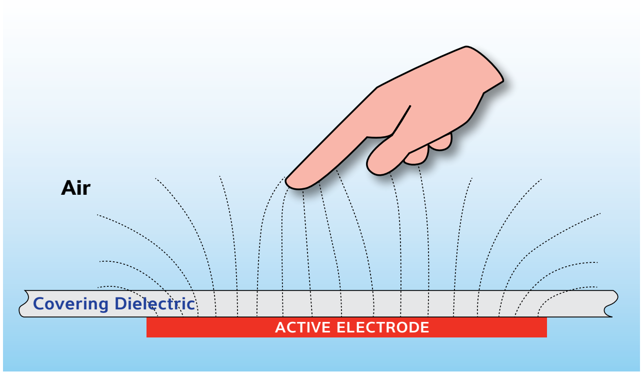

Figure 6. Self-capacitive Sensor Geometry

The electric field lines responsible for touch/proximity detection are generated away from the sensor uniformly in all directions. The generation of the electric field in this manner allows for the highest possible proximity detection of any sensor.

Flexible Sensor Tuning – Achieve the desired sensor sensitivity and proximity detection range required for the end application through simple hardware modifications and adjustable firmware settings.

Environmental Performance – QTouch fast charge operates to the same high standards as the QTouch and QMatrix touch product lines. It has excellent immunity to noise and moisture.

Summary

QTouch fast charge is Atmel's preferred touch acquisition method for passive entry proximity detection applications. The QTouch fast charge proximity implementation has extremely low power consumption, fast response time, and provides exceptionally good proximity detection range. These features, when paired with Atmel's low-frequency transceiver product line, provide the foundation of a car access passive entry proximity detection system for the next generation.